INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

Atlanta, Georgia

LINERBOARD HANDSHEETS FOR USDA FOREST PRODUCTS LABORATORY

Project 3881

Final Report

A Progress Report

to

U.S. DEPARTMENT OF AGRICULTURE
FOREST PRODUCTS LABORATORY
MADISON, WI

By

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May 1, 1994

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PROJECT REPORT

Subject: Linerboard Handsheets for USDA Forest Products Laboratory

Project No.: 3881

Project Staff: Irwin M. Hutten

Abstract

Single-ply linerboard handsheets, targeted at 42 lb/1000ft^2 (205 gsm) were produced on the Formette Dynamique handsheet former for the USDA Forest Service, Forest Products Laboratory in Madison, Wisconsin. The handsheets were produced in accordance with a factorial design that included furnish pulps from three linerboard maunufacturers, three levels of MD:CD fiber orientation, two levels of wet pressing, and two levels of drying restraint. The finished handsheets were tested for wet handsheet consistency, shrinkage during drying, basis weight, caliper, density, and ultrasonic properties. The handsheets along with the data have been supplied to the client. The client will test the handsheets for cyclic humidity creep behavior.

Background

The USDA Forest Products Laboratory (FPL) in Madison, Wisconsin, the sponsor of this project, has entered into a contract with the Container and Kraft Paper Group (CKPG) of the American Forest and Paper Association to determine the effect of important furnish and process variables on paperboard and to determine the importance of paperboard hygroexpansivity on the top-to-bottom compressive creep performance of corrugated containers. To conduct this study, FPL asked IPST to produce Formette Dynamique handsheets made under the various furnish and process variable conditions.

Objectives

1. Produce Formette Dynamique handsheets in accordance with the factorial design of Table 1.

2. Test the handsheets for wet handsheet consistency, dimensional change during drying, basis weight, caliper, density, and ultrasonic properties.

3. Provide the handsheets along with the associated data to the client.

Recommendations and Conclusions

1. The handsheets and associated data have been provided to the client in accordance with the objectives and scope of this project.

2. Detailed statistical analysis was not within the scope of this project. However, visual examination of the data indicates some very interesting possibilities for relating process conditions to handsheet properties. Some of these are:

    a. The effect of fiber type and fiber orientation on handsheet consistency which is related to drainage.

    b. The effect of process conditions (fiber orientation, wet pressing, and drying restraint) on dimensional change during drying.

3. It is recommended that the handsheets be measured for Ring Crush and/or STFI. This will provide the opportunity to relate the compressive strength properties to the process conditions of fiber orientation, wet pressing, and drying restraint, and to determine how the process conditions affect the correlations with ultrasonic properties. Of particular interest would be the three levels of fiber orientation and how this affects the correlations of CD properties.

Summary

Handsheets, targeted at 42 lb/1000ft^2, were prepared on the "Formette Dynamique" handsheet former. Furnishes included unbleached kraft pulps supplied from three different mills: Inland Container (Recycle), Longview Fibre (West), and MacMillan Bloedel (South). Process variables included three levels of bowl speed (MD:CD ratio), two levels of refining, and two levels of drying restraint.

Stock was prepared in a Noble and Woods beater at 2.0-2.5% consistency and beaten with a 40-lb weight to 500 ml Canadian Standard Freeness. Prepared stock, diluted to 0.5% consistency, was fed to the Formette Dynamique handsheet former from an attached 20-liter mix vessel. Different levels of MD:CD ratio were achieved by changing the speed of the centrifugal forming bowl of the Formette.

The wet formed sheets were wet pressed in a Baldwin Press, five sheets at a time. The wet pressing cycles were 5 minutes at 50 psi for the low level and 5 minutes at 50 psi followed by 5 minutes at 100 psi for the high level. The wet pressed sheets were dried in a rotary steam heated drum dryer for 12 minutes. Two levels of

drying restraint were achieved by adjusting the tension of the drying fabric that pressed the handsheets to the surface of the dryer drum, 0 psi for low level and 50 psi for high level. The effectiveness of the drying restraint was determined by MD and CD shrinkage of the handsheets during drying. Handsheet consistency was determined from the weight of the bone-dry handsheet divided by the weight of the wet handsheet when removed from the Formette forming bowl. Handsheet consistency is an indicator of drainage; the wetter the handsheet, the poorer the drainage.

Finished handsheets were cut into 8" x 16" segments for shipment to the client. They were tested for basis weight, caliper, and ultrasonic properties. Ultrasonic properties included Z-direction as well as in-plane properties. The test results along with related process conditions are presented in Appendix Tables IA-C.

Discussion

A. Experimental Procedures

1. Pulp Preparation

a. Furnish Identification

Fiber furnish materials were supplied by Longview Fibre, MacMillan Bloedel, and Inland Container. They are identified in Table 1 as follows:

Longview Fibre - West

MacMillan Bloedel - South

Inland Container - Recycle

b. Refining

The pulps from 1.a above were blended, diluted and refined in a 100 liter Valley beater. 2200 grams of pulp (bone dry basis) were added to 100 liters of water for a consistency of 2.2%. The stock was beaten or refined with a 40-lb weight to the targeted Canadian Standard Freeness (CSF) of 500 ml.

c. Stock Dilution

A 50-gallon agitated mix tank was used for diluting the beater prepared stock to 0.5% consistency.

d. Stock Feed

The volume of stock added to the Formette from each mix vessel is targeted to produce a 2.05 ft^2 handsheet weighing 36 grams. This is equivalent to a bone-dry basis weight of 39

lb/1000ft^2. and a basis weight of 42 lb/1000 ft^2 at 7% moisture. Targeted volume based on 0.5% consistency was 7200 ml. Volumes were adjusted based on actual measured consistencies in the mix tank.

2. Sheet Formation

a. Description of Formette Dynamique

The Formette Dynamique is a centrifugal sheet former. Stock is sprayed onto a Fourdrinier wire covering the inside of the centrifuge bowl. The bowl contains two concentric walls: a solid outer wall and a perforated plenum inner wall. The forming fabric is placed around the inside of the perforated inner wall. Actually, two fabrics are used: a coarse plastic fabric on the wall which is in turn covered by a fine fabric. When the Formette is operated, water is added to the bowl so that it completely covers the fabric and forms a wall over it. It is important to note that when stock is sprayed, it is not sprayed directly onto the fabric, but rather on the water wall covering the fabric.

The water wall level or thickness is maintained constant by a radial (or circular) weir located underneath the perforated inner wall of the centrifuge bowl. There is a continuous flow of water through the forming fabric, through the perforated inner wall, and down into the radial chamber beneath. When the handsheet is being formed, the water overflows at the radial weir and into a drainage section underneath the centrifuge bowl.

Underneath the centrifuge bowl, there is also a scoop that when engaged moves into the radial chamber between the perforated wall and the radial weir. It "scoops out" or deflects the water from the radial chamber into the drainage section. In this way, the centrifugal action is used to dewater the handsheet after it is formed in the centrifuge bowl.

The spray nozzle is attached to an inlet feed that oscillates up and down. The up and down path covers the full vertical width of the centrifuge bowl's inner perforated wall. The nozzle used for this study was a Spraying Systems Inc. Vee Jet H1/4 2510. It emits a 25-degree, fan-shaped spray pattern at a rate of 60 cc/sec when pressurized to 2 bars.

b. Sheet Forming Procedure

The water wall is built by adding approximately 5 liters of water into the centrifuge bowl. Bowl speed is maintained at 1050 m/min. Completion of the water wall is identified by a color change on the wire as it becomes covered with water.

The up and down oscillator and the water pump are turned on, and a flow of purge water is initiated from the 20-liter supply vessel of the Formette to the spray nozzle. While this purge water is being pumped, the centrifuge speed is adjusted to the desired forming speed: 730 m/min for low MD:CD ratio, 825 m/min for middle MD:CD ratio and 1500 m/min for high ratio. Simultaneously, the nozzle pressure is adjusted to 2 bars.

Just before the purge water is emptied from the 20-liter feed vessel, a carefully measured volume of stock for the bottom ply is added to the feed vessel and sheet formation begins. During the addition of stock, pump pressure is maintained at 2 bars and bowl speed at the desired rate mentioned above. One to two liters of purge water is added to the feed vessel just before the stock is emptied. This is to flush the spray nozzle line.

Upon completion of flow, the centrifuge speed is increased or maintained to 1500 m/min to remove water from the bowl and dewater the formed sheet. The scoop is engaged and the water removal step lasts about 30-60 seconds or until the sound of discharging water disappears. The centrifuge bowl is then braked to a stop. The wet formed sheet is removed and weighed.

c. Forming Conditions

1) Basis weight:
   Bone-dry: 39 lb/1000ft^2
   At 7% moist.: 42 lb/1000ft^2

2) Pump pressure: 2 bars - equivalent to 60 cc/sec.

3) Centrifuge bowl speeds
   building water wall: 1050 m/min
   sheet formation:
   For high MD:CD ratio - 1500 m/min
   For middle MD:CD ratio - 825 m/min
   For low MD:CD ratio - 720 m/min
   sheet drainage - 1500 m/min

4) Spray nozzle - Vee Jet H 1/4 2510

3. Pressing and Drying

After weighing, five wet formed sheets from each experimental design condition were sandwiched between blotters for wet pressing. The sandwich consisted of two blotters, a sheet, two blotters, a sheet, two blotters, etc., always with two blotters on either side

of the sandwich. The five sheets, so sandwiched, were placed between plates for pressing in the Baldwin press. The wet pressing cycle was 15,000 lb (equivalent to 50 psi) for 5 minutes for the low level and 15,000 lb for 5 minutes followed by 30,000 lb (equivalent to 100 psi) for 5 minutes for the high level.

The sheets were dried individually in the steam heated drum dryer for 12 minutes while sandwiched between blotters until bone dry.

The finished sheets, approximately 8 1/2" x 35", were weighed for basis weight.

B. Test Methods

1. TAPPI Tests

Standard TAPPI test methods were used for all tests except caliper and ultrasonic properties. Caliper was measured by the IPST soft caliper method and as part of Z-direction ultrasonic testing (see 2 below).

2. Ultrasonic Testing

The ultrasonic robot at IPST was used for all in-plane ultrasonic tests. The IPST ultrasonic Z-direction tester was used for out of plane ultrasonic tests. This instrument is also equipped to do soft caliper measurements.

C. Experimental Design

Table 1 is the factorial design for this study. It includes the following factors:

a. Furnish - Three types of pulp provided by Longview Fibre (West), MacMillan Bloedel (South), and Inland Container (Recycle).

b. Three levels of bowl speed for MD:CD ratio: 720 m/min for low ratio, 825 m/min for middle ratio, and 1500 m/min for high ratio.

c. Two levels of wet pressing: 5 min at 50 psi for the low level and 5 min at 50 psi followed by 5 min at 100 psi for the high level.

d. Two levels of drying restraint based on the felt tension of the drying fabric against the drum dryer: 0 psi for low level and 50 psi for high level.

D. Discussion of Results

1. Spreadsheet Organization

Appendix I contains the tabulated results of all tests. Appendix I.A defines the column headings. Appendix Tables I.B and I.C are summarized as follows:

Table I.B - Lists process conditions, handsheet consistency, shrinkage, and physical properties (basis weight, caliper, and density).

Table I.C - Lists all of the ultrasonic properties.

2. Data Analysis

Visual examination of the data in Appendix Tables I.B and I.C indicates a number of possible interesting correlations, regressions, and comparisons. This work is beyond the scope of this project; however, the analytical work may be useful for future studies. Possibilities are:

1. The relationship of handsheet consistency (drainage) to process variables.

2. The relationship of shrinkage to drying restraint, to other process variables, and to fiber orientation.

3. The relationships between ultrasonic properties and process variables.

3. MD - CD Effects

One of the major issues facing linerboard manufacturers is the relationships between linerboard properties and box crush strength. Of particular interest are the MD - CD effects such as geometric mean and MD:CD ratio. Since this study was conducted at three levels of MD:CD ratio, there is an excellent opportunity to relate this variable to other linerboard properties such as Ring Crush and STFI. The testing for Ring Crush and STFI still has to be done; however, the handsheet samples will be kept available for this possibility.

Acknowledgement

The author wishes to acknowledge the initiative of Charles Jeffrey who provided the conscientious assistance necessary to prepare the handsheets.

Signature Page

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Table 1. FPL CKPG Project: Experimental Design							
Orientation MD:CD (Bowl Speed m/min)	Wet Pressing Level	Furnish					
		West		South		Recycled	
		Drying Restraint Level		Drying Restraint Level		Drying Restraint Level	
		Low	High	Low	High	Low	High
720	Low						
	High						
825	Low						
	High						
1500	Low						
	High						

APPENDIX I.A

EXPLANATION OF COLUMN HEADINGS IN DATA TABLES

CODE - A four-digit number that identifies process conditions as follows:

First digit - Furnish Identification:

1 - Longview

2 - Inland

3 - MacMillan Bloedel

Second digit - Bowl Speed:

1 - 720 m/min

2 - 825 m/min

3 - 1500 m/min

Third digit - Wet Pressing Level:

1 - 50 psi for 5 min

2 - 50 psi for 5 min followed by 100 psi for 5 min

Fourth digit - Drying Restraint Level:

1 - 0 psi

2 - 50 psi

NBPG - Notebook page where handsheet is identified.

SAMPLE - Sample number on that notebook page that identifies the handsheet.

SUPPLIER- The provider of the pulp used for the handsheet.

BOWLSPEED - The Formette Dynamique bowl speed at which the handsheet was formed. A high bowl speed (1500 m/min) results in a high MD:CD ratio. An in-between bowl speed (825 m/min) results in an in-between MD:CD ratio. A low bowl speed (720 m/min) results in a low ratio.

DRYING RESTRAINT - The pressure of the drum dryer felt tension when the handsheet was dried.

CONS - The bone-dry fiber content of the wet handsheet as it is removed from the Formette bowl.

MDSHRINK - The MD shrinkage, in percent, based on 80 cm marked off on the handsheet before drying, but after wet pressing.

CDSHRINK - The CD shrinkage, in percent, based on 20 cm marked off on the handsheet before drying, but after wet pressing.

BWTG - Basis weight in g/sq.m.

CAL - Caliper in micrometers.

DENS - Density in g/cc.

VSQMD - Ultrasonic velocity squared, machine direction $(m/sec)^2$

VSQCD - Ultrasonic velocity squared, cross direction $(m/sec)^2$.

RATIO - MD:CD ratio = VSQMD/VSQCD

VSQGM - Geometric mean ultrasonic velocity squared = $(VSQMD*VSQCD)^{0.5}$, $(m/sec)^2$.

VSQCDSHR - CD shear by ultrasonic measurement $(m/sec)^2$.

EX - Ultrasonic modulus E_x, machine direction = VSQMDxDENx(1-POISVXYxPOISVYX), (GPA).

EY - Ultrasonic modulus E_y, cross direction =VSQCDxDENx(1-POISVXYxPOISVYX), (GPA).

EXT - Ultrasonic extensional stiffness E_xt, machine direction.

EYT - Ultrasonic extensional stiffness E_yt, cross direction.

ETGM - Geometric mean ultrasonic extensional stiffness squared, ETGM = $(ETX*ETY)^{0.5}$.

Appendix Table I.B

CODE	NBPG	SAMPLE	Supplier	Bowl Speed	Wet Press	Drying Restraint	CONS	MDSHRINK	CDSHRINK	BWTG	CAL	DENS
1111	3935-56	13	Longview	720 m/m	50 psi	0 psi	15.1	.57	1.27	.	.	.
	3935-56	14	Longview	720 m/m	50 psi	0 psi	15.1	.69	2.04	.	.	.
	3935-56	15	Longview	720 m/m	50 psi	0 psi	15.1	.69	2.04	200.9	359.5	.559
	3935-56	16	Longview	720 m/m	50 psi	0 psi	15.2	.69	1.78	200.3	346.0	.579
	3935-56	17	Longview	720 m/m	50 psi	0 psi	15.2	.69	2.04	200.5	349.1	.574
Mean		15		1	1	1	15.1	.67	1.83	200.6	351.5	.571
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.0	.06	.34	.3	7.1	.011
1112	3935-56	3	Longview	720 m/m	50 psi	50 psi	14.9	.63	1.52	.	.	.
	3935-56	4	Longview	720 m/m	50 psi	50 psi	15.1	.57	1.01	199.7	318.3	.627
	3935-56	5	Longview	720 m/m	50 psi	50 psi	15.0	.57	1.01	202.4	325.1	.623
	3935-56	6	Longview	720 m/m	50 psi	50 psi	14.8	.63	1.27	201.4	321.5	.626
	3935-56	7	Longview	720 m/m	50 psi	50 psi	14.8	.63	1.27	.	.	.
Mean		5		1	1	2	14.9	.60	1.21	201.2	321.6	.625
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.1	.03	.21	1.4	3.4	.002
1121	3935-56	18	Longview	720 m/m	50psi + 100 psi	0 psi	14.8	.88	2.56	.	.	.
	3935-56	19	Longview	720 m/m	50psi + 100 psi	0 psi	15.2	.76	1.78	.	.	.
	3935-56	20	Longview	720 m/m	50psi + 100 psi	0 psi	15.2	.76	2.30	203.3	279.3	.728
	3935-56	21	Longview	720 m/m	50psi + 100 psi	0 psi	15.2	.88	2.04	202.6	277.0	.731
	3935-56	22	Longview	720 m/m	50psi + 100 psi	0 psi	15.3	.82	1.94	200.9	271.0	.741
Mean		20		1	2	1	15.1	.82	2.12	202.3	275.8	.734
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.06	.31	1.2	4.3	.007
1122	3935-56	8	Longview	720 m/m	50psi + 100 psi	50 psi	14.3	.63	1.52	.	.	.
	3935-56	9	Longview	720 m/m	50psi + 100 psi	50 psi	15.4	.50	1.27	.	.	.
	3935-56	10	Longview	720 m/m	50psi + 100 psi	50 psi	14.5	.57	1.01	207.6	261.3	.794
	3935-56	11	Longview	720 m/m	50psi + 100 psi	50 psi	14.7	.57	1.01	195.3	254.1	.769
	3935-56	12	Longview	720 m/m	50psi + 100 psi	50 psi	14.4	.57	1.01	200.7	265.9	.755
Mean		10		1	2	2	14.6	.57	1.16	201.2	260.4	.773
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.4	.04	.23	6.1	5.9	.020
1211	3935-57	3	Longview	825 m/min	50 psi	0 psi	14.0	.63	2.04	210.2	381.2	.551
	3935-57	4	Longview	825 m/min	50 psi	0 psi	14.0	.63	2.04	210.4	386.1	.545
	3935-57	5	Longview	825 m/min	50 psi	0 psi	14.0	.82	2.30	212.9	367.2	.580
	3935-57	6	Longview	825 m/min	50 psi	0 psi	14.0	.63	2.30	.	.	.
	3935-57	7	Longview	825 m/min	50 psi	0 psi	14.1	.63	2.30	.	.	.
Mean		5		2	1	1	14.0	.67	2.20	211.2	378.2	.559
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.0	.09	.14	1.5	9.8	.019
1212	3935-57	8	Longview	825 m/min	50 psi	50 psi	14.3	.38	1.52	.	.	.
	3935-57	9	Longview	825 m/min	50 psi	50 psi	14.4	.44	1.52	.	.	.
	3935-57	10	Longview	825 m/min	50 psi	50 psi	14.2	.50	1.78	209.5	357.1	.587
	3935-57	11	Longview	825 m/min	50 psi	50 psi	14.4	.44	1.78	210.0	358.5	.586
	3935-57	12	Longview	825 m/min	50 psi	50 psi	14.3	.57	1.78	209.7	354.4	.592
Mean		10		2	1	2	14.3	.46	1.68	209.7	356.7	.588
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.1	.07	.14	.3	2.1	.003

Appendix Table I.B (cont'd)

CODE	NBPG	SAMPLE	Supplier	Bowl Speed	Wet Press	Drying Restraint	CONS	MDSHRINK	CDSHRINK	BWTG	CAL	DENS
1221	3935-57	18	Longview	825 m/min	50psi + 100 psi	0 psi	14.4	.57	2.04	211.8	289.4	.732
	3935-57	19	Longview	825 m/min	50psi + 100 psi	0 psi	14.6	.63	2.04	210.0	288.2	.729
	3935-57	20	Longview	825 m/min	50psi + 100 psi	0 psi	14.6	.63	2.30	209.6	288.1	.728
	3935-57	21	Longview	825 m/min	50psi + 100 psi	0 psi	14.7	.63	2.04	.	.	.
	3935-57	22	Longview	825 m/min	50psi + 100 psi	0 psi	14.6	.63	2.04	.	.	.
Mean		20		2	2	1	14.6	.62	2.09	210.5	288.6	.729
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.1	.03	.12	1.2	.7	.002
1222	3935-57	13	Longview	825 m/min	50psi + 100 psi	50 psi	14.4	.44	1.78	.	.	.
	3935-57	14	Longview	825 m/min	50psi + 100 psi	50 psi	14.5	.44	1.78	.	.	.
	3935-57	15	Longview	825 m/min	50psi + 100 psi	50 psi	14.3	.44	2.04	209.9	280.9	.747
	3935-57	16	Longview	825 m/min	50psi + 100 psi	50 psi	14.3	.44	2.04	209.6	280.1	.748
	3935-57	17	Longview	825 m/min	50psi + 100 psi	50 psi	14.3	.44	2.04	208.6	276.8	.754
Mean		15		2	2	2	14.4	.44	1.94	209.4	279.3	.750
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.1	.00	.14	.7	2.2	.003
1311	3935-58	1	Longview	1500m/m	50 psi	0 psi	14.4	.69	2.30	.	.	.
	3935-58	2	Longview	1500m/m	50 psi	0 psi	14.4	.57	2.04	.	.	.
	3935-58	3	Longview	1500m/m	50 psi	0 psi	14.1	.69	2.30	217.3	376.3	.577
	3935-58	4	Longview	1500m/m	50 psi	0 psi	14.1	.69	2.46	216.8	358.5	.605
	3935-58	5	Longview	1500m/m	50 psi	0 psi	14.3	.63	2.41	213.8	346.5	.617
Mean		3		3	1	1	14.2	.65	2.30	216.0	360.4	.600
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.06	.16	1.9	15.0	.020
1312	3935-58	6	Longview	1500m/m	50 psi	50 psi	14.7	.40	1.27	201.8	323.8	.623
	3935-58	7	Longview	1500m/m	50 psi	50 psi	14.8	.40	1.52	202.8	321.2	.631
	3935-58	8	Longview	1500m/m	50 psi	50 psi	14.5	.44	1.52	206.2	325.7	.633
	3935-58	9	Longview	1500m/m	50 psi	50 psi	14.7	.31	1.01	.	.	.
	3935-58	10	Longview	1500m/m	50 psi	50 psi	14.7	.50	1.78	.	.	.
Mean		8		3	1	2	14.7	.41	1.42	203.6	323.6	.629
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.1	.07	.29	2.3	2.3	.005
1321	3935-58	16	Longview	1500m/m	50psi + 100 psi	0 psi	13.9	.88	4.71	.	.	.
	3935-58	17	Longview	1500m/m	50psi + 100 psi	0 psi	14.0	.69	4.71	.	.	.
	3935-58	18	Longview	1500m/m	50psi + 100 psi	0 psi	14.3	.76	3.90	209.8	251.8	.833
	3935-58	19	Longview	1500m/m	50psi + 100 psi	0 psi	14.2	.88	3.63	204.5	262.8	.778
	3935-58	20	Longview	1500m/m	50psi + 100 psi	0 psi	14.0	.76	3.63	208.5	267.5	.779
Mean		18		3	2	1	14.1	.79	4.11	207.6	260.7	.797
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.09	.56	2.7	8.1	.031
1322	3935-58	11	Longview	1500m/m	50psi + 100 psi	50 psi	14.2	.38	2.30	204.3	259.8	.786
	3935-58	12	Longview	1500m/m	50psi + 100 psi	50 psi	14.2	.31	1.52	205.6	269.2	.764
	3935-58	13	Longview	1500m/m	50psi + 100 psi	50 psi	14.1	.50	1.78	205.7	274.1	.750
	3935-58	14	Longview	1500m/m	50psi + 100 psi	50 psi	14.1	.50	2.30	.	.	.
	3935-58	15	Longview	1500m/m	50psi + 100 psi	50 psi	13.8	.38	1.52	.	.	.
Mean		13		3	2	2	14.1	.41	1.89	205.2	267.7	.767
N	5	5	5	5	5	5	5	5	5	3	3	3

Appendix Table I.B (cont'd)

CODE	NBPG	SAMPLE	Supplier	Bowl Speed	Wet Press	Drying Restraint	CONS	MDSHRINK	CDSHRINK	BWTG	CAL	DENS
StdDev		2		0	0	0	.2	.08	.39	.8	7.3	.018
2111	3935-60	1	Inland	720 m/m	50 psi	0 psi	16.7	.57	1.52	.	.	.
	3935-60	2	Inland	720 m/m	50 psi	0 psi	16.8	.50	1.78	.	.	.
	3935-60	3	Inland	720 m/m	50 psi	0 psi	17.5	.57	1.52	205.0	402.7	.509
	3935-60	4	Inland	720 m/m	50 psi	0 psi	17.4	.50	1.52	197.9	415.0	.477
	3935-60	5	Inland	720 m/m	50 psi	0 psi	17.1	.50	1.52	200.0	411.4	.486
Mean		3		1	1	1	17.1	.53	1.57	201.0	409.7	.491
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.3	.04	.12	3.6	6.3	.017
2112	3935-60	6	Inland	720 m/m	50 psi	50 psi	17.3	.50	1.27	200.1	394.3	.507
	3935-60	7	Inland	720 m/m	50 psi	50 psi	16.9	.38	1.52	201.8	399.8	.505
	3935-60	8	Inland	720 m/m	50 psi	50 psi	17.1	.44	1.52	197.2	380.4	.519
	3935-60	9	Inland	720 m/m	50 psi	50 psi	17.4	.44	1.27	.	.	.
	3935-60	10	Inland	720 m/m	50 psi	50 psi	17.1	.44	.50	.	.	.
Mean		8		1	1	2	17.1	.44	1.22	199.7	391.5	.510
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.04	.42	2.3	10.0	.007
2121	3935-60	11	Inland	720 m/m	50psi + 100 psi	0 psi	16.6	.57	1.78	200.2	308.0	.650
	3935-60	12	Inland	720 m/m	50psi + 100 psi	0 psi	16.7	.63	1.78	201.7	310.6	.649
	3935-60	13	Inland	720 m/m	50psi + 100 psi	0 psi	16.9	.63	1.63	198.9	305.4	.651
	3935-60	14	Inland	720 m/m	50psi + 100 psi	0 psi	16.6	.57	1.78	.	.	.
	3935-60	15	Inland	720 m/m	50psi + 100 psi	0 psi	16.7	.57	1.78	.	.	.
Mean		13		1	2	1	16.7	.59	1.75	200.2	308.0	.650
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.1	.03	.07	1.4	2.6	.001
2122	3935-60	16	Inland	720 m/m	50psi + 100 psi	50 psi	15.9	.44	1.27	.	.	.
	3935-60	17	Inland	720 m/m	50psi + 100 psi	50 psi	16.9	.50	1.01	.	.	.
	3935-60	18	Inland	720 m/m	50psi + 100 psi	50 psi	16.9	.50	1.27	199.9	307.9	.649
	3935-60	19	Inland	720 m/m	50psi + 100 psi	50 psi	16.4	.48	1.01	202.8	312.8	.648
	3935-60	20	Inland	720 m/m	50psi + 100 psi	50 psi	16.8	.44	1.01	203.4	307.5	.661
Mean		18		1	2	2	16.6	.47	1.11	202.0	309.4	.653
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.4	.03	.14	1.9	3.0	.007
2211	3935-61	6	Inland	825 m/min	50 psi	0 psi	16.2	.57	2.04	203.4	410.2	.496
	3935-61	7	Inland	825 m/min	50 psi	0 psi	15.9	.50	1.52	205.1	406.4	.505
	3935-61	8	Inland	825 m/min	50 psi	0 psi	15.9	.50	2.04	205.9	410.0	.502
	3935-61	9	Inland	825 m/min	50 psi	0 psi	15.9	.53	1.99	.	.	.
	3935-61	10	Inland	825 m/min	50 psi	0 psi	16.3	.57	1.52	.	.	.
Mean		8		2	1	1	16.0	.53	1.82	204.8	408.9	.501
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.03	.28	1.3	2.1	.005
2212	3935-61	1	Inland	825 m/min	50 psi	50 psi	16.1	.38	.76	204.5	383.6	.533
	3935-61	2	Inland	825 m/min	50 psi	50 psi	16.4	.38	.86	203.7	378.1	.539
	3935-61	3	Inland	825 m/min	50 psi	50 psi	16.1	.38	.76	198.0	368.2	.538
	3935-61	4	Inland	825 m/min	50 psi	50 psi	15.9	.38	1.01	.	.	.
	3935-61	5	Inland	825 m/min	50 psi	50 psi	16.1	.38	.76	.	.	.
Mean		3		2	1	2	16.1	.38	.83	202.1	376.6	.537

Appendix Table I.B (cont'd)

CODE	NBPG	SAMPLE	Supplier	Bowl Speed	Wet Press	Drying Restraint	CONS	MDSHRINK	CDSHRINK	BWTG	CAL	DENS
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.00	.11	3.6	7.8	.003
2221	3935-61	11	Inland	825 m/min	50psi + 100 psi	0 psi	16.6	.57	2.04	203.7	304.8	.668
	3935-61	12	Inland	825 m/min	50psi + 100 psi	0 psi	16.2	.63	2.04	203.9	307.0	.664
	3935-61	13	Inland	825 m/min	50psi + 100 psi	0 psi	16.1	.69	2.04	204.0	313.6	.651
	3935-61	14	Inland	825 m/min	50psi + 100 psi	0 psi	16.1	.63	2.04	.	.	.
	3935-61	15	Inland	825 m/min	50psi + 100 psi	0 psi	15.7	.69	2.04	.	.	.
Mean		13		2	2	1	16.1	.64	2.04	203.9	308.5	.661
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.3	.05	.00	.2	4.6	.009
2222	3935-61	16	Inland	825 m/min	50psi + 100 psi	50 psi	15.4	.50	1.01	203.6	308.1	.661
	3935-61	17	Inland	825 m/min	50psi + 100 psi	50 psi	15.7	.44	1.01	200.0	303.1	.660
	3935-61	18	Inland	825 m/min	50psi + 100 psi	50 psi	15.9	.44	1.01	204.0	310.0	.658
	3935-61	19	Inland	825 m/min	50psi + 100 psi	50 psi	15.8	.38	1.01	.	.	.
	3935-61	20	Inland	825 m/min	50psi + 100 psi	50 psi	15.7	.38	.76	.	.	.
Mean		18		2	2	2	15.7	.43	.96	202.5	307.1	.660
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.05	.11	2.2	3.6	.001
2311	3935-63	1	Inland	1500m/m	50 psi	0 psi	15.7	.50	2.04	.	.	.
	3935-63	2	Inland	1500m/m	50 psi	0 psi	16.0	.57	2.15	.	.	.
	3935-63	3	Inland	1500m/m	50 psi	0 psi	15.9	.69	2.30	207.5	406.9	.510
	3935-63	4	Inland	1500m/m	50 psi	0 psi	15.8	.50	2.04	209.3	405.4	.516
	3935-63	5	Inland	1500m/m	50 psi	0 psi	15.9	.69	2.04	207.8	394.3	.527
Mean		3		3	1	1	15.8	.59	2.11	208.2	402.2	.518
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.1	.10	.11	1.0	6.9	.009
2312	3935-63	6	Inland	1500m/m	50 psi	50 psi	16.1	.44	1.01	205.7	389.4	.528
	3935-63	7	Inland	1500m/m	50 psi	50 psi	16.1	.38	1.01	202.4	380.8	.532
	3935-63	8	Inland	1500m/m	50 psi	50 psi	15.9	.38	1.01	204.8	385.4	.531
	3935-63	9	Inland	1500m/m	50 psi	50 psi	15.9	.44	1.01	.	.	.
	3935-63	10	Inland	1500m/m	50 psi	50 psi	15.9	.31	1.01	.	.	.
Mean		8		3	1	2	16.0	.39	1.01	204.3	385.2	.530
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.1	.05	.00	1.7	4.3	.002
2321	3935-63	11	Inland	1500m/m	50psi + 100 psi	0 psi	15.9	.48	1.52	209.3	325.1	.644
	3935-63	12	Inland	1500m/m	50psi + 100 psi	0 psi	16.4	.50	1.52	202.3	312.9	.647
	3935-63	13	Inland	1500m/m	50psi + 100 psi	0 psi	16.1	.63	2.04	200.0	314.8	.635
	3935-63	14	Inland	1500m/m	50psi + 100 psi	0 psi	15.8	.57	1.52	.	.	.
	3935-63	15	Inland	1500m/m	50psi + 100 psi	0 psi	16.5	.50	1.42	.	.	.
Mean		13		3	2	1	16.2	.54	1.61	203.9	317.6	.642
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.3	.06	.25	4.8	6.6	.006
2322	3935-63	16	Inland	1500m/m	50psi + 100 psi	50 psi	16.4	.38	1.52	.	.	.
	3935-63	17	Inland	1500m/m	50psi + 100 psi	50 psi	16.4	.38	1.52	.	.	.
	3935-63	18	Inland	1500m/m	50psi + 100 psi	50 psi	16.0	.38	1.01	203.9	316.3	.645
	3935-63	19	Inland	1500m/m	50psi + 100 psi	50 psi	16.0	.31	1.27	204.4	312.0	.655
	3935-63	20	Inland	1500m/m	50psi + 100 psi	50 psi	15.9	.31	1.27	207.2	305.6	.678

Appendix Table I.B (cont'd)

CODE	NBPG	SAMPLE	Supplier	Bowl Speed	Wet Press	Drying Restraint	CONS	MDSHRINK	CDSHRINK	BWTG	CAL	DENS
Mean		18		3	2	2	16.1	.35	1.32	205.2	311.3	.659
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.03	.21	1.8	5.4	.017
3111	3935-65	1	Mac. Bloedel	720 m/m	50 psi	0 psi	14.2	1.01	2.83	218.4	438.8	.498
	3935-65	2	Mac. Bloedel	720 m/m	50 psi	0 psi	14.6	.69	2.83	209.1	401.7	.520
	3935-65	3	Mac. Bloedel	720 m/m	50 psi	0 psi	14.5	.88	2.04	216.6	436.9	.496
	3935-65	4	Mac. Bloedel	720 m/m	50 psi	0 psi	15.1	1.01	2.56	.	.	.
	3935-65	5	Mac. Bloedel	720 m/m	50 psi	0 psi	14.9	1.01	3.36	.	.	.
Mean		3		1	1	1	14.7	.92	2.72	214.7	425.8	.505
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.3	.14	.48	4.9	20.9	.014
3112	3935-65	11	Mac. Bloedel	720 m/m	50 psi	50 psi	15.5	.50	1.52	212.2	386.2	.550
	3935-65	12	Mac. Bloedel	720 m/m	50 psi	50 psi	15.5	.63	1.01	216.1	395.0	.547
	3935-65	13	Mac. Bloedel	720 m/m	50 psi	50 psi	16.4	.50	1.78	217.8	388.9	.560
	3935-65	14	Mac. Bloedel	720 m/m	50 psi	50 psi	15.5	.57	1.27	.	.	.
	3935-65	15	Mac. Bloedel	720 m/m	50psi + 100 psi	50 psi	15.6	.57	1.01	.	.	.
Mean		13		1	1	2	15.7	.55	1.32	215.4	390.0	.552
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.4	.05	.33	2.9	4.5	.007
3121	3935-65	6	Mac. Bloedel	720 m/m	50psi + 100 psi	0 psi	15.4	.95	2.56	.	.	.
	3935-65	7	Mac. Bloedel	720 m/m	50psi + 100 psi	0 psi	14.1	.76	2.04	.	.	.
	3935-65	8	Mac. Bloedel	720 m/m	50psi + 100 psi	0 psi	14.8	1.14	3.63	221.7	318.3	.696
	3935-65	9	Mac. Bloedel	720 m/m	50psi + 100 psi	0 psi	14.8	1.01	3.09	216.2	316.5	.683
	3935-65	10	Mac. Bloedel	720 m/m	50psi + 100 psi	0 psi	14.8	.88	2.30	217.9	303.1	.719
Mean		8		1	2	1	14.8	.95	2.73	218.6	312.6	.699
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.4	.14	.64	2.8	8.3	.018
3122	3935-65	16	Mac. Bloedel	720 m/m	50psi + 100 psi	50 psi	15.3	.50	1.52	203.0	289.2	.702
	3935-65	17	Mac. Bloedel	720 m/m	50psi + 100 psi	50 psi	15.4	.50	1.01	194.6	273.7	.711
	3935-65	18	Mac. Bloedel	720 m/m	50psi + 100 psi	50 psi	14.8	.50	1.52	198.6	274.7	.723
	3935-65	19	Mac. Bloedel	720 m/m	50psi + 100 psi	50 psi	14.9	.50	1.52	.	.	.
Mean		18		1	2	2	15.1	.50	1.39	198.7	279.2	.712
N	4	4	4	4	4	4	4	4	4	3	3	3
StdDev		1		0	0	0	.3	.00	.26	4.2	8.7	.011
3211	3935-67	1	Mac. Bloedel	825 m/min	50 psi	0 psi	14.6	1.07	3.09	.	.	.
	3935-67	2	Mac. Bloedel	825 m/min	50 psi	0 psi	14.1	1.14	2.56	216.8	391.2	.554
	3935-67	3	Mac. Bloedel	825 m/min	50 psi	0 psi	14.8	1.27	3.36	.	.	.
	3935-67	4	Mac. Bloedel	825 m/min	50 psi	0 psi	14.1	1.14	2.56	214.5	387.3	.554
	3935-67	5	Mac. Bloedel	825 m/min	50 psi	0 psi	14.3	1.52	3.63	215.1	393.4	.547
Mean		3		2	1	1	14.4	1.23	3.04	215.4	390.6	.552
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.3	.18	.47	1.2	3.1	.004
3212	3935-67	16	Mac. Bloedel	825 m/min	50 psi	50 psi	15.0	.63	1.27	215.8	359.0	.601
	3935-67	17	Mac. Bloedel	825 m/min	50 psi	50 psi	14.7	.57	1.27	210.7	341.1	.618
	3935-67	18	Mac. Bloedel	825 m/min	50 psi	50 psi	15.1	.50	1.52	213.4	351.9	.606
	3935-67	19	Mac. Bloedel	825 m/min	50 psi	50 psi	15.1	.50	1.78	.	.	.
	3935-67	20	Mac. Bloedel	825 m/min	50 psi	50 psi	14.9	.50	1.52	.	.	.

Appendix Table I.B (cont'd)

CODE	NBPG	SAMPLE	Supplier	Bowl Speed	Wet Press	Drying Restraint	CONS	MDSHRINK	CDSHRINK	BWTG	CAL	DENS
Mean		18		2	1	2	15.0	.54	1.47	213.3	350.7	.608
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.06	.22	2.5	9.0	.009
3221	3935-67	6	Mac. Bloedel	825 m/min	50psi + 100 psi	0 psi	15.2	.95	2.56	212.3	284.8	.745
	3935-67	7	Mac. Bloedel	825 m/min	50psi + 100 psi	0 psi	14.5	.82	2.56	216.6	300.9	.720
	3935-67	8	Mac. Bloedel	825 m/min	50psi + 100 psi	0 psi	14.4	1.14	3.63	213.0	298.4	.714
	3935-67	9	Mac. Bloedel	825 m/min	50psi + 100 psi	0 psi	14.5	.88	3.09	.	.	.
	3935-67	10	Mac. Bloedel	825 m/min	50psi + 100 psi	0 psi	14.1	.88	3.63	.	.	.
Mean		8		2	2	1	14.5	.93	3.09	213.9	294.7	.726
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.4	.12	.53	2.3	8.7	.017
3222	3935-67	11	Mac. Bloedel	825 m/min	50psi + 100 psi	50 psi	14.5	.63	1.78	211.5	281.0	.753
	3935-67	12	Mac. Bloedel	825 m/min	50psi + 100 psi	50 psi	14.0	.50	1.78	213.5	285.5	.748
	3935-67	13	Mac. Bloedel	825 m/min	50psi + 100 psi	50 psi	14.3	.50	2.04	212.7	275.6	.772
	3935-67	14	Mac. Bloedel	825 m/min	50psi + 100 psi	50 psi	14.6	.50	1.78	.	.	.
	3935-67	15	Mac. Bloedel	825 m/min	50psi + 100 psi	50 psi	14.2	.50	1.27	.	.	.
Mean		13		2	2	2	14.3	.53	1.73	212.6	280.7	.757
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.06	.28	1.0	5.0	.013
3311	3935-68	11	Mac. Bloedel	1500m/m	50 psi	0 psi	13.7	.63	2.56	212.9	344.3	.618
	3935-68	12	Mac. Bloedel	1500m/m	50 psi	0 psi	13.3	.63	2.04	214.0	350.2	.611
	3935-68	13	Mac. Bloedel	1500m/m	50 psi	0 psi	13.3	.69	2.83	214.3	357.2	.600
	3935-68	14	Mac. Bloedel	1500m/m	50 psi	0 psi	13.6	.63	2.30	.	.	.
	3935-68	15	Mac. Bloedel	1500m/m	50 psi	0 psi	13.7	.63	2.30	.	.	.
Mean		13		3	1	1	13.5	.64	2.41	213.7	350.6	.610
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.03	.30	.7	6.5	.009
3312	3935-68	1	Mac. Bloedel	1500m/m	50 psi	50 psi	13.3	.50	1.27	.	.	.
	3935-68	2	Mac. Bloedel	1500m/m	50 psi	50 psi	13.2	.50	1.52	.	.	.
	3935-68	3	Mac. Bloedel	1500m/m	50 psi	50 psi	13.6	.50	1.27	217.2	340.8	.637
	3935-68	4	Mac. Bloedel	1500m/m	50 psi	50 psi	13.6	.50	1.78	215.6	342.5	.630
	3935-68	5	Mac. Bloedel	1500m/m	50 psi	50 psi	13.2	.50	1.52	220.9	330.3	.669
Mean		3		3	1	2	13.4	.50	1.47	217.9	337.9	.645
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.2	.00	.22	2.7	6.6	.021
3321	3935-68	16	Mac. Bloedel	1500m/m	50psi + 100 psi	0 psi	13.2	.76	3.36	.	.	.
	3935-68	17	Mac. Bloedel	1500m/m	50psi + 100 psi	0 psi	13.8	.69	2.30	.	.	.
	3935-68	18	Mac. Bloedel	1500m/m	50psi + 100 psi	0 psi	13.2	.82	3.36	213.8	273.3	.782
	3935-68	19	Mac. Bloedel	1500m/m	50psi + 100 psi	0 psi	13.3	.82	3.90	213.5	290.2	.736
	3935-68	20	Mac. Bloedel	1500m/m	50psi + 100 psi	0 psi	13.2	.88	3.63	216.3	287.9	.751
	3935-68	21	Mac. Bloedel	1500m/m	50psi + 100 psi	0 psi	13.4	.88	3.63	.	.	.
Mean		19		3	2	1	13.3	.81	3.36	214.5	283.8	.756
N	6	6	6	6	6	6	6	6	6	3	3	3
StdDev		2		0	0	0	.2	.07	.56	1.5	9.2	.024
3322	3935-68	6	Mac. Bloedel	1500m/m	50psi + 100 psi	50 psi	14.0	.44	1.52	214.7	269.8	.796
	3935-68	7	Mac. Bloedel	1500m/m	50psi + 100 psi	50 psi	13.8	.44	1.78	217.9	272.7	.799
	3935-68	8	Mac. Bloedel	1500m/m	50psi + 100 psi	50 psi	14.5	.50	2.04	219.4	273.3	.803

Appendix Table I.B (cont'd)

CODE	NBPG	SAMPLE	Supplier	Bowl Speed	Wet Press	Drying Restraint	CONS	MDSHRINK	CDSHRINK	BWTG	CAL	DENS
3322	3935-68	9	Mac. Bloedel	1500m/m	50psi + 100 psi	50 psi	14.1	.50	2.56	.	.	.
	3935-68	10	Mac. Bloedel	1500m/m	50psi + 100 psi	50 psi	14.1	.63	2.56	.	.	.
Mean		8		3	2	2	14.1	.50	2.09	217.3	271.9	.799
N	5	5	5	5	5	5	5	5	5	3	3	3
StdDev		2		0	0	0	.3	.08	.47	2.4	1.9	.003
Grand Total												
Mean		11		2	2	1	15.1	.60	1.90	207.8	331.4	.640
N	180	180	180	180	180	180	180	180	180	108	108	108
StdDev		6		1	1	1	1.1	.20	.78	6.5	48.9	.093

Appendix Table I.C

CODE	NBPG	SAMPLE	VSQMD	VSQCD	RATIO	VSQGM	VSQCDSH	VSQZD	EXT	EYT	ETGM
1111	3935-56	13	.	.	.	.	.	.	.	.	.
	3935-56	14	.	.	.	.	.	.	.	.	.
	3935-56	15	13.69	9.58	1.43	11.45	3.80	.089	2450	1715	2050
	3935-56	16	14.01	10.39	1.35	12.06	3.91	.107	2469	1831	2127
	3935-56	17	14.26	9.95	1.43	11.91	3.84	.112	2511	1751	2097
Mean		15	13.99	9.97	1.40	11.81	3.85	.103	2477	1766	2091
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.29	.40	.05	.32	.06	.012	31	60	39
1112	3935-56	3	.	.	.	.	.	.	.	.	.
	3935-56	4	14.64	10.36	1.41	12.32	4.06	.132	2596	1837	2184
	3935-56	5	13.11	10.82	1.21	11.91	3.95	.132	2359	1946	2143
	3935-56	6	13.77	11.44	1.20	12.55	4.04	.125	2427	2016	2212
	3935-56	7	.	.	.	.	.	.	.	.	.
Mean		5	13.84	10.87	1.28	12.26	4.02	.130	2460	1933	2179
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.77	.54	.12	.33	.06	.004	122	90	35
1121	3935-56	18	.	.	.	.	.	.	.	.	.
	3935-56	19	.	.	.	.	.	.	.	.	.
	3935-56	20	14.46	11.32	1.28	12.79	4.20	.164	2604	2039	2304
	3935-56	21	14.02	11.58	1.21	12.74	4.01	.173	2465	2037	2241
	3935-56	22	15.10	11.99	1.26	13.45	4.36	.183	2668	2117	2377
Mean		20	14.53	11.63	1.25	13.00	4.19	.173	2579	2064	2307
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.54	.34	.03	.40	.18	.010	103	46	68
1122	3935-56	8	.	.	.	.	.	.	.	.	.
	3935-56	9	.	.	.	.	.	.	.	.	.
	3935-56	10	15.07	12.63	1.19	13.80	4.42	.193	2726	2285	2495
	3935-56	11	15.03	11.62	1.29	13.22	4.60	.174	2676	2069	2353
	3935-56	12	14.53	12.29	1.18	13.36	4.47	.180	2601	2201	2393
Mean		10	14.88	12.18	1.22	13.46	4.50	.182	2667	2185	2414
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.30	.51	.06	.30	.09	.010	63	109	73
1211	3935-57	3	18.30	6.37	2.87	10.79	3.36	.097	3479	1210	2052
	3935-57	4	19.23	6.27	3.07	10.98	3.37	.111	3653	1191	2086
	3935-57	5	17.98	6.35	2.83	10.68	3.32	.098	3443	1215	2045
	3935-57	6	.	.	.	.	.	.	.	.	.
	3935-57	7	.	.	.	.	.	.	.	.	.
Mean		5	18.50	6.33	2.93	10.82	3.35	.102	3525	1205	2061
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.65	.05	.12	.15	.03	.008	112	13	22
1212	3935-57	8	.	.	.	.	.	.	.	.	.
	3935-57	9	.	.	.	.	.	.	.	.	.
	3935-57	10	19.19	6.70	2.86	11.34	3.52	.123	3636	1269	2148
	3935-57	11	19.94	6.96	2.87	11.78	3.48	.128	3694	1289	2182
	3935-57	12	19.64	6.76	2.91	11.52	3.48	.135	3681	1267	2159
Mean		10	19.59	6.81	2.88	11.55	3.49	.129	3670	1275	2163
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.38	.14	.02	.22	.02	.006	30	12	17

Appendix Table I.C (Cont'd)

CODE	NBPG	SAMPLE	VSQMD	VSQCD	RATIO	VSQGM	VSQCDSH	VSQZD	EXT	EYT	ETGM
1221	3935-57	18	20.17	7.61	2.65	12.39	3.89	.207	3857	1456	2370
	3935-57	19	20.30	7.64	2.66	12.45	3.86	.197	3812	1435	2339
	3935-57	20	19.76	7.06	2.80	11.82	3.66	.195	3725	1332	2227
	3935-57	21	.	.	.	.	.	.	.	.	.
	3935-57	22	.	.	.	.	.	.	.	.	.
Mean		20	20.08	7.44	2.70	12.22	3.80	.200	3798	1407	2312
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.28	.32	.08	.35	.12	.006	67	66	75
1222	3935-57	13	.	.	.	.	.	.	.	.	.
	3935-57	14	.	.	.	.	.	.	.	.	.
	3935-57	15	20.26	7.54	2.69	12.36	3.90	.214	3832	1426	2338
	3935-57	16	21.08	8.30	2.54	13.22	4.17	.219	3967	1562	2489
	3935-57	17	20.98	7.78	2.70	12.78	4.03	.226	3953	1466	2408
Mean		15	20.77	7.87	2.64	12.79	4.03	.220	3918	1485	2412
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.45	.39	.09	.43	.13	.006	74	70	76
1311	3935-58	1	.	.	.	.	.	.	.	.	.
	3935-58	2	.	.	.	.	.	.	.	.	.
	3935-58	3	22.72	4.64	4.90	10.26	2.96	.112	4582	935	2069
	3935-58	4	21.18	4.35	4.87	9.60	2.88	.142	4325	888	1959
	3935-58	5	23.45	4.74	4.95	10.54	3.04	.142	4653	940	2091
Mean		3	22.45	4.57	4.91	10.13	2.96	.132	4520	921	2040
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	1.16	.20	.04	.48	.08	.017	173	29	71
1312	3935-58	6	22.46	4.66	4.82	10.23	3.14	.152	4312	894	1963
	3935-58	7	23.48	4.75	4.94	10.56	3.16	.159	4483	907	2016
	3935-58	8	21.75	4.63	4.70	10.03	3.15	.164	4282	911	1975
	3935-58	9	.	.	.	.	.	.	.	.	.
	3935-58	10	.	.	.	.	.	.	.	.	.
Mean		8	22.56	4.68	4.82	10.27	3.15	.158	4359	904	1985
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.87	.06	.12	.27	.01	.006	109	9	28
1321	3935-58	16	.	.	.	.	.	.	.	.	.
	3935-58	17	.	.	.	.	.	.	.	.	.
	3935-58	18	20.66	4.87	4.24	10.03	3.26	.229	4152	979	2017
	3935-58	19	21.91	5.25	4.17	10.73	3.41	.210	4254	1020	2083
	3935-58	20	22.38	4.99	4.48	10.57	3.33	.230	4451	993	2103
Mean		18	21.65	5.04	4.30	10.44	3.33	.223	4286	997	2067
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.89	.19	.16	.36	.08	.011	152	21	45
1322	3935-58	11	25.53	5.32	4.80	11.65	3.54	.220	4924	1025	2247
	3935-58	12	24.40	4.96	4.92	11.00	3.25	.215	4708	957	2123
	3935-58	13	25.08	5.28	4.75	11.50	3.31	.204	4743	998	2175
	3935-58	14	.	.	.	.	.	.	.	.	.
	3935-58	15	.	.	.	.	.	.	.	.	.
Mean		13	25.01	5.18	4.83	11.39	3.36	.213	4792	993	2182
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.57	.20	.08	.34	.15	.008	116	34	62

Appendix Table I.C (Cont'd)

CODE	NBPG	SAMPLE	VSQMD	VSQCD	RATIO	VSQGM	VSQCDSH	VSQZD	EXT	EYT	ETGM
2111	3935-60	1	.	.	.	.	.	.	.	.	.
	3935-60	2	.	.	.	.	.	.	.	.	.
	3935-60	3	9.04	7.22	1.25	8.08	2.64	.087	1636	1305	1461
	3935-60	4	8.53	7.76	1.10	8.13	2.67	.076	1488	1353	1419
	3935-60	5	8.52	7.52	1.13	8.00	2.67	.086	1519	1341	1427
Mean		3	8.70	7.50	1.16	8.07	2.66	.083	1547	1333	1436
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.30	.27	.08	.07	.02	.006	78	25	23
2112	3935-60	6	9.63	7.19	1.34	8.32	2.83	.097	1740	1299	1503
	3935-60	7	8.94	7.51	1.19	8.19	2.81	.101	1626	1366	1490
	3935-60	8	8.73	8.23	1.06	8.48	2.85	.103	1535	1446	1490
	3935-60	9	.	.	.	.	.	.	.	.	.
	3935-60	10	.	.	.	.	.	.	.	.	.
Mean		8	9.10	7.64	1.20	8.33	2.83	.100	1634	1370	1494
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.47	.53	.14	.14	.02	.003	102	74	7
2121	3935-60	11	9.92	8.59	1.16	9.23	3.12	.118	1778	1539	1654
	3935-60	12	10.11	8.63	1.17	9.34	3.06	.118	1797	1534	1660
	3935-60	13	9.77	8.11	1.20	8.90	3.05	.121	1750	1454	1595
	3935-60	14	.	.	.	.	.	.	.	.	.
	3935-60	15	.	.	.	.	.	.	.	.	.
Mean		13	9.93	8.44	1.18	9.16	3.08	.119	1775	1509	1637
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.17	.29	.02	.23	.04	.002	23	48	36
2122	3935-60	16	.	.	.	.	.	.	.	.	.
	3935-60	17	.	.	.	.	.	.	.	.	.
	3935-60	18	10.44	9.13	1.14	9.76	3.22	.127	1846	1615	1727
	3935-60	19	10.88	8.25	1.32	9.47	3.11	.132	1948	1477	1696
	3935-60	20	9.88	8.96	1.10	9.41	3.17	.133	1797	1630	1712
Mean		18	10.40	8.78	1.19	9.55	3.16	.131	1864	1574	1712
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.50	.47	.12	.19	.05	.003	77	85	15
2211	3935-61	6	11.89	5.06	2.35	7.76	2.36	.081	2117	902	1382
	3935-61	7	11.76	5.45	2.16	8.00	2.46	.093	2110	978	1437
	3935-61	8	11.42	5.06	2.26	7.60	2.39	.091	2093	926	1393
	3935-61	9	.	.	.	.	.	.	.	.	.
	3935-61	10	.	.	.	.	.	.	.	.	.
Mean		8	11.69	5.19	2.25	7.79	2.40	.088	2107	936	1404
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.24	.23	.10	.20	.05	.006	12	39	29
2212	3935-61	1	12.04	5.78	2.08	8.34	2.65	.106	2190	1052	1518
	3935-61	2	11.81	5.64	2.09	8.16	2.61	.107	2146	1025	1483
	3935-61	3	13.60	6.08	2.24	9.09	2.66	.109	2309	1032	1544
	3935-61	4	.	.	.	.	.	.	.	.	.
	3935-61	5	.	.	.	.	.	.	.	.	.
Mean		3	12.48	5.84	2.14	8.53	2.64	.107	2215	1036	1515
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.98	.22	.09	.49	.03	.002	84	14	30

Appendix Table I.C (Cont'd)

CODE	NBPG	SAMPLE	VSQMD	VSQCD	RATIO	VSQGM	VSQCDSH	VSQZD	EXT	EYT	ETGM
2221	3935-61	11	12.42	6.05	2.05	8.67	2.71	.133	2232	1087	1558
	3935-61	12	12.19	6.48	1.88	8.89	2.85	.121	2212	1175	1612
	3935-61	13	11.65	6.08	1.92	8.42	2.72	.126	2121	1107	1532
	3935-61	14	.	.	.	.	.	.	.	.	.
	3935-61	15	.	.	.	.	.	.	.	.	.
Mean		13	12.09	6.20	1.95	8.66	2.76	.127	2188	1123	1567
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.39	.24	.09	.23	.08	.006	59	46	41
2222	3935-61	16	12.95	6.71	1.93	9.32	2.91	.138	2314	1199	1665
	3935-61	17	13.49	6.12	2.21	9.09	2.88	.140	2407	1091	1621
	3935-61	18	13.18	6.54	2.01	9.29	2.87	.138	2353	1168	1658
	3935-61	19	.	.	.	.	.	.	.	.	.
	3935-61	20	.	.	.	.	.	.	.	.	.
Mean		18	13.21	6.46	2.05	9.23	2.89	.139	2358	1153	1648
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.27	.30	.14	.13	.02	.001	47	55	24
2311	3935-63	1	.	.	.	.	.	.	.	.	.
	3935-63	2	.	.	.	.	.	.	.	.	.
	3935-63	3	12.73	3.94	3.23	7.08	2.13	.089	2371	734	1319
	3935-63	4	13.01	4.05	3.22	7.26	2.14	.092	2456	764	1370
	3935-63	5	12.13	3.97	3.05	6.94	2.15	.101	2293	751	1312
Mean		3	12.63	3.99	3.17	7.09	2.14	.094	2373	749	1333
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.45	.06	.10	.16	.01	.006	82	15	32
2312	3935-63	6	12.46	4.15	3.00	7.19	2.25	.098	2336	778	1348
	3935-63	7	13.39	3.97	3.37	7.29	2.22	.103	2453	728	1336
	3935-63	8	13.10	4.41	2.97	7.60	2.27	.103	2392	805	1388
	3935-63	9	.	.	.	.	.	.	.	.	.
	3935-63	10	.	.	.	.	.	.	.	.	.
Mean		8	12.98	4.18	3.11	7.36	2.25	.101	2394	770	1357
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.48	.22	.22	.21	.03	.003	59	39	27
2321	3935-63	11	13.46	4.21	3.19	7.53	2.33	.116	2563	802	1434
	3935-63	12	13.21	4.24	3.11	7.49	2.38	.116	2459	790	1394
	3935-63	13	13.42	4.65	2.88	7.90	2.46	.114	2432	844	1432
	3935-63	14	.	.	.	.	.	.	.	.	.
	3935-63	15	.	.	.	.	.	.	.	.	.
Mean		13	13.36	4.37	3.06	7.64	2.39	.115	2485	812	1420
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.13	.25	.16	.23	.07	.001	69	28	23
2322	3935-63	16	.	.	.	.	.	.	.	.	.
	3935-63	17	.	.	.	.	.	.	.	.	.
	3935-63	18	13.19	4.54	2.90	7.74	2.44	.120	2444	841	1434
	3935-63	19	13.88	4.80	2.89	8.17	2.52	.132	2552	883	1501
	3935-63	20	13.79	4.88	2.82	8.21	2.82	.151	2565	908	1526
Mean		18	13.62	4.74	2.87	8.04	2.59	.134	2520	878	1487
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.37	.18	.04	.26	.20	.016	67	34	48

Appendix Table I.C (Cont'd)

CODE	NBPG	SAMPLE	VSQMD	VSQCD	RATIO	VSQGM	VSQCDSH	VSQZD	EXT	EYT	ETGM
3111	3935-65	1	12.15	8.15	1.49	9.95	3.05	.071	2274	1527	1863
	3935-65	2	13.50	9.30	1.45	11.21	3.40	.082	2407	1658	1998
	3935-65	3	12.27	8.46	1.45	10.18	3.15	.081	2286	1576	1898
	3935-65	4	.	.	.	.	.	.	.	.	.
	3935-65	5	.	.	.	.	.	.	.	.	.
Mean		3	12.64	8.64	1.46	10.45	3.20	.078	2323	1587	1920
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.75	.59	.02	.67	.18	.006	74	66	70
3112	3935-65	11	13.39	9.57	1.40	11.32	3.39	.096	2401	1717	2030
	3935-65	12	12.86	9.35	1.38	10.96	3.36	.097	2367	1720	2017
	3935-65	13	12.46	9.16	1.36	10.68	3.46	.100	2388	1755	2047
	3935-65	14	.	.	.	.	.	.	.	.	.
	3935-65	15	.	.	.	.	.	.	.	.	.
Mean		13	12.90	9.36	1.38	10.99	3.40	.098	2385	1731	2032
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.47	.21	.02	.32	.05	.002	18	21	15
3121	3935-65	6	.	.	.	.	.	.	.	.	.
	3935-65	7	.	.	.	.	.	.	.	.	.
	3935-65	8	13.05	9.15	1.43	10.93	3.52	.145	2539	1782	2127
	3935-65	9	13.13	9.35	1.40	11.08	3.60	.144	2500	1781	2110
	3935-65	10	13.13	9.41	1.40	11.11	3.74	.158	2567	1839	2173
Mean		8	13.10	9.30	1.41	11.04	3.62	.149	2535	1801	2137
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.05	.13	.02	.10	.11	.008	33	33	32
3122	3935-65	16	14.16	10.38	1.36	12.12	3.88	.158	2520	1848	2158
	3935-65	17	13.43	10.13	1.33	11.66	3.78	.160	2299	1735	1997
	3935-65	18	15.36	10.65	1.44	12.79	3.92	.162	2602	1804	2166
	3935-65	19	.	.	.	.	.	.	.	.	.
Mean		18	14.32	10.39	1.38	12.19	3.86	.160	2474	1796	2107
N	4	4	3	3	3	3	3	3	3	3	3
StdDev		1	.98	.26	.06	.57	.07	.002	157	57	95
3211	3935-67	1	.	.	.	.	.	.	.	.	.
	3935-67	2	14.41	6.74	2.14	9.85	3.08	.093	2764	1293	1890
	3935-67	3	.	.	.	.	.	.	.	.	.
	3935-67	4	13.30	6.70	1.98	9.44	3.03	.092	2550	1285	1810
	3935-67	5	12.42	6.15	2.02	8.73	2.84	.090	2406	1191	1693
Mean		3	13.37	6.53	2.05	9.34	2.98	.092	2573	1256	1798
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	1.00	.33	.08	.57	.13	.002	180	57	99
3212	3935-67	16	12.93	9.74	1.33	11.22	3.83	.109	2519	1898	2186
	3935-67	17	15.48	8.88	1.74	11.73	3.59	.123	2814	1615	2132
	3935-67	18	15.19	8.15	1.86	11.12	3.58	.120	2891	1551	2118
	3935-67	19	.	.	.	.	.	.	.	.	.
	3935-67	20	.	.	.	.	.	.	.	.	.
Mean		18	14.53	8.92	1.64	11.36	3.67	.117	2741	1688	2145
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	1.39	.80	.28	.32	.14	.007	196	184	36

Appendix Table I.C (Cont'd)

CODE	NBPG	SAMPLE	VSQMD	VSQCD	RATIO	VSQGM	VSQCDSH	VSQZD	EXT	EYT	ETGM
3221	3935-67	6	15.26	8.11	1.88	11.13	3.40	.155	.	.	.
	3935-67	7	15.66	8.38	1.87	11.45	3.56	.149	2959	1583	2165
	3935-67	8	14.15	8.16	1.73	10.75	3.38	.141	2632	1518	1999
	3935-67	9	.	.	.	.	.	.	.	.	.
	3935-67	10	.	.	.	.	.	.	.	.	.
Mean		8	15.02	8.22	1.83	11.11	3.45	.148	2796	1551	2082
N	5	5	3	3	3	3	3	3	2	2	2
StdDev		2	.78	.14	.08	.35	.10	.007	232	46	117
3222	3935-67	11	17.14	7.78	2.20	11.55	3.70	.167	3242	1471	2184
	3935-67	12	16.92	8.67	1.95	12.11	3.85	.166	3204	1643	2294
	3935-67	13	17.36	8.79	1.98	12.35	3.80	.177	3232	1636	2299
	3935-67	14	.	.	.	.	.	.	.	.	.
	3935-67	15	.	.	.	.	.	.	.	.	.
Mean		13	17.14	8.41	2.04	12.00	3.78	.170	3226	1583	2259
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.22	.55	.14	.41	.08	.006	20	97	65
3311	3935-68	11	18.24	4.68	3.89	9.24	2.92	.111	3659	940	1854
	3935-68	12	19.74	5.29	3.73	10.22	3.03	.120	3824	1025	1980
	3935-68	13	18.49	4.91	3.77	9.53	2.88	.117	3630	963	1870
	3935-68	14	.	.	.	.	.	.	.	.	.
	3935-68	15	.	.	.	.	.	.	.	.	.
Mean		13	18.82	4.96	3.80	9.66	2.95	.116	3704	976	1902
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	.80	.31	.09	.50	.08	.005	104	44	68
3312	3935-68	1	.	.	.	.	.	.	.	.	.
	3935-68	2	.	.	.	.	.	.	.	.	.
	3935-68	3	18.39	6.48	2.84	10.92	3.29	.142	3547	1250	2106
	3935-68	4	18.53	5.88	3.15	10.44	3.14	.131	3586	1137	2019
	3935-68	5	20.42	6.04	3.38	11.11	3.31	.152	4058	1201	2207
Mean		3	19.11	6.13	3.12	10.82	3.24	.142	3730	1196	2111
N	5	5	3	3	3	3	3	3	3	3	3
StdDev		2	1.13	.31	.27	.35	.09	.011	284	57	94
3321	3935-68	16	.	.	.	.	.	.	.	.	.
	3935-68	17	.	.	.	.	.	.	.	.	.
	3935-68	18	18.31	5.98	3.07	10.46	3.34	.176	3628	1184	2072
	3935-68	19	18.80	5.58	3.37	10.24	3.22	.168	3706	1100	2019
	3935-68	20	18.30	5.81	3.15	10.31	3.20	.175	3600	1143	2028
	3935-68	21	.	.	.	.	.	.	.	.	.
Mean		19	18.47	5.79	3.19	10.34	3.25	.173	3645	1142	2040
N	6	6	3	3	3	3	3	3	3	3	3
StdDev		2	.28	.20	.16	.11	.07	.004	55	42	28
3322	3935-68	6	20.07	6.79	2.96	11.67	3.48	.186	3809	1288	2215
	3935-68	7	20.88	6.79	3.07	11.91	3.52	.195	4038	1313	2303
	3935-68	8	18.76	6.68	2.81	11.19	3.52	.180	3738	1331	2231
	3935-68	9	.	.	.	.	.	.	.	.	.
	3935-68	10	.	.	.	.	.	.	.	.	.
Mean		8	19.90	6.75	2.95	11.59	3.51	.187	3861	1311	2249
N	5	5	3	3	3	3	3	3	3	3	3

Appendix Table I.C (Cont'd)

CODE	NBPG	SAMPLE	VSQMD	VSQCD	RATIO	VSQGM	VSQCDSH	VSQZD	EXT	EYT	ETGM
StdDev		2	1.07	.06	.13	.36	.02	.008	157	22	47
Grand Total											
Mean		11	15.48	7.20	2.41	10.29	3.24	.137	2904	1331	1915
N	180	180	108	108	108	108	108	108	107	107	107
StdDev		6	4.13	2.20	1.11	1.73	.57	.040	864	381	330